Energy, Mines and Resources Canada

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Énergie, Mines et Ressources Canada

L'Hon. Marcel Masse
Ministre

URANIUM IN CANADA 1986

ASSESSMENT of SUPPLY and REQUIREMENTS

Canada

Canada—World's Leading Producer

URANIUM IN CANADA

1986 ASSESSMENT OF SUPPLY AND REQUIREMENTS

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EXECUTIVE SUMMARY

Canadian uranium exploration and development efforts in 1985 and 1986 resulted in a significant increase in estimates of measured uranium resources, as shown in the table below. New discoveries have more than made up for production during 1985 and 1986, and for the elimination of some resources from the overall estimates, due to the sustained upward pressure on production costs and the stagnation of uranium prices in real terms.

Principal Resource Categories	Tonnes U* Recoverable From Mineable Ore	
	1984	1986
Measured	54 000	70 000
Indicated	233 000	235 000
Inferred	264 000	262 000
Total	551 000	567 000

Canada possesses a large portion of the world's uranium resources that are of current economic interest and remains the major focus of international uranium exploration activity. The Athabasca Basin in northern Saskatchewan is recognized as the principal target for the discovery of very high grade uranium deposits.

Expenditures for uranium exploration in Canada in 1985 and 1986 were $32 million and $33 million, respectively. Although much lower than the $130 million total reported for 1979, expenditures for 1987 are forecast to increase. Exploration and surface development drilling in 1985 and 1986 were reported to be 183 000 m and 162 000 m, respectively, 85 per cent of which was in Saskatchewan.

Canada has maintained its position as the world's leading producer and exporter of uranium. In 1986, Canada's five primary uranium producers employed some 5100 workers and produced concentrates containing 11 723 tU. Based on existing production centres, Canada's projected annual uranium production capability is expected to stabilize at some 12 000 tU through the late 1990s. Should market conditions warrant, production capability could be increased beyond 15 000 tU by the latter half of the 1990s; in comparison, world requirements will approach 60 000 tU/year.

By the year 2000, Canada's annual uranium requirements will be about 2 100 tU. Canada's known uranium resources are more than sufficient to meet the 30-year fuel requirements of those reactors in Canada that are either in operation now or expected to be in service by the late 1990s. A substantial portion of Canada's identified uranium resources is thus surplus to Canadian needs and available for export.

Annual sales currently approach $1 billion, of which exports account for 85 per cent. Forward domestic and export contract commitments totalled 73 000 tU and 62 000 tU, respectively, as of early 1987.

Over the longer term, there is significant potential for discovering additional uranium resources in Canada. With increasing demand for uranium, much of this potential will no doubt be realized and developed. Canada is assured of being able to supply its own needs while contributing to those of its trading partners for many years to come.

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* One metric ton (tonne) of elemental uranium (U), written as tU, is equivalent in terms of uranium content to 1.2999 short tons of uranium oxide (U_3O_8).

CANADIAN URANIUM INDUSTRY

FACT SHEET

	1986	1985	1984
Canadian Uranium Production (tU)			
Ontario - Rio Algom	2 813	2 840	2 917
Ontario - Denison	2 015	2 112	2 246
Saskatchewan - Key Lake	4 834	4 270	4 003
Saskatchewan - Eldorado	1 227	824	1 361
Saskatchewan - Cluff Mining	834	834	642
Total Production (tU)	11 723	10 880	11 169
Share of Western World Output (%)	31%	31%	28%
Canadian Uranium Requirements (tU)	1 400	1 300	1 300
Uranium Shipments From Ontario Producers (tU)	4 752	4 499	4 552
Value of Shipments ($C millions)	$566	$553	$545
Uranium Shipments From Saskatchewan Producers (tU)	6 750	5 942	5 720
Value of Shipments ($C millions)	$476	$450	$357
Average Export Price for Annual Deliveries ($C/kg U)	$89	$91	$90
($US/lb U_3O_8)	$25	$26	$27
Average Annual "NUEXCO" Spot Market Price ($US/lb U_3O_8)	$17.00	$15.60	$17.27
Share of Canadian Export Deliveries Under Spot Price Agreements (%)	21%	20%	26%
Actual Exports of Uranium of Canadian Origin (tU)	9 096	8 294	6 937
Uranium Exploration Expenditures in Canada ($C millions)	$33	$32	$35
Employment as of December 31 (Mine + Mill + General)	5,080	5,333	5,811

PART 1. SHORT-TERM PERSPECTIVE

1. SUPPLY

a) Supply Sources

Measured, Indicated and Inferred Tonnages

Canadian uranium supply over the next 10 to 15 years will be drawn from known resources, estimates of which are divided into three categories, measured, indicated and inferred, reflecting different levels of confidence in the reported quantities.(1) Estimates of 1986 resources in these three categories, prepared by EMR's Uranium Resource Appraisal Group (URAG), are presented in Table 1. The bulk of these resources is associated with deposits identified in Figure 1.

A comparison of 1986 estimates of Canada's uranium resources with those from the 1984 resource assessment (2) (see Table 1), indicates a shift in resources from the less well-defined to the better-defined categories; this reflects the continued delineation of recently discovered uranium deposits in Saskatchewan. There has also been a significant increase in resources of current interest (i.e., A + B price categories); this is attributed partly to new discoveries, and partly to the reassignment by URAG of some resources to lower price categories.

Of the combined measured, indicated and inferred resources presented in Table 1, about 42 per cent is in Ontario and 52 per cent in Saskatchewan. Distributions quoted in the 1980 assessment were 63 and 31 per cent, respectively. The change reflects the continued discovery and delineation of high-quality uranium resources in northern Saskatchewan.

About half of Canada's known uranium resources occur in Proterozoic unconformity-related type deposits, primarily in northern Saskatchewan (see Figure 2). These deposits contain either monometallic (Eagle Point) or polymetallic (Key Lake, Collins Bay B Zone, Cigar Lake) mineralization associated with the sub-Athabasca unconformity. Pitchblende mineralization prevails in the monometallic deposits, whereas uranium-nickel-cobalt assemblages prevail in the polymetallic deposits. Average grades vary from less than 1 per cent U in some deposits to between 2 and 5 per cent U in others, while parts of certain deposits (Cigar Lake) grade more than 10 per cent U.

Most of Canada's other known uranium resources occur in quartz-pebble conglomerates, primarily in the Elliot Lake area of Ontario. Mineralization occurs at the base of the Huronian Supergroup in several beds containing ores grading on average between 0.05 and 0.1 per cent U.

b) Uranium Availability

Existing Operations

In January 1986, Canada had five primary uranium producers: Denison Mines Limited, Rio Algom Limited, Eldorado Resources Limited, Key Lake Mining Corporation (KLMC) and Cluff Mining. The key data for the related uranium production centres are summarized in Table 2.

The first two producers, located in the Elliot Lake area of Ontario, operate conventional underground mines, and both use in-place leaching techniques for additional recovery of uranium. The other three are located in the Athabasca region of northern

TABLE 1. **Estimates of Canada's Uranium Resources Recoverable from Mineable Ore**[a]

Price ranges within which mineable ore is assessed[b]	Thousands of tonnes of uranium					
	Measured		Indicated		Inferred	
	1986	1984	1986	1984	1986	1984
A	46	31	107	124	112	105
B	1	-	95	59	99	92
A + B	47	31	202	183	211	197
C	23	23	33	50	51	67
A + B + C	70	54	235	233	262	264

a Actual or expected losses in mining recovery as well as in ore processing have been accounted for; these factors were individually applied to resources tributary to existing and prospective production centres. In underground operations, mineable ore is generally 75 to 85 per cent of the ore-in-place; higher mining recoveries are achievable in open-pit operations. Ore-processing recoveries in Canada normally range from 90 to 97 per cent. The 1986 weighted average mill recovery of Canada's existing conventional uranium operations was 96 per cent.

b The price figures, given in Canadian dollars/kg U, reflect the price of a quantity of uranium concentrate containing 1 kg of elemental uranium. The prices were used in determining the cut-off grade at each deposit assessed, taking into account the mining method used and the processing losses expected.

The price ranges are (A) $100/kg U or less, (B) between $100 and $150/kg U, and (C) between $150 and $300/kg U. The price of $100/kg U was used by URAG for its assessment to illustrate those resources that were of economic interest to Canada in 1986, and served to define the upper limit of the A price category.

Only resources in the lower two price categories (A and B) are used by EMR for the purpose of determining whether resource levels are sufficient to meet domestic requirements. Resources in the third (C) price category are not expected to be of economic interest before the late 1990s.

$1/lb U_3O_8 = $2.6/kg U

Saskatchewan. Two produce from open pits whereas the third is partly an open-pit and partly an underground operation.

Production from the primary uranium producers increased by about 8 per cent from 1985 to 1986. The difference is largely due to the Key Lake operation exceeding its nominal annual output of 4 600 tU per year. Preliminary estimates of 1986 shipments of uranium made by Canada's producers was 10 977 tU, worth some $923 million. Differences between annual production and shipment figures reflect inventory quantities.

In 1986, almost 60 per cent of Canada's total uranium production and shipments came from Saskatchewan and the balance from Ontario.

At Elliot Lake, Ontario, Denison Mines Limited continues to match uranium production to requirements under its long-term contracts. Milling is restricted to the new, more efficient, semi-autogenous facility, permitting the shut-down of the conventional crushing and grinding plant; mill recovery increased to 94 per cent. Productivity improvements of 12 per cent were realized in 1986, as Denison achieved its output target.

During 1987, Denison acquired the mining claims of Canuc Resources Inc. located to the southwest of the Denison mine; the company expects to prove up additional uranium resources for inclusion in future production plans. With nearly 54 000 tU remaining to be delivered under domestic and export contracts through the year 2012, Denison will continue measures to reduce operating costs and increase productivity in order to remain competitive.

FIGURE 1

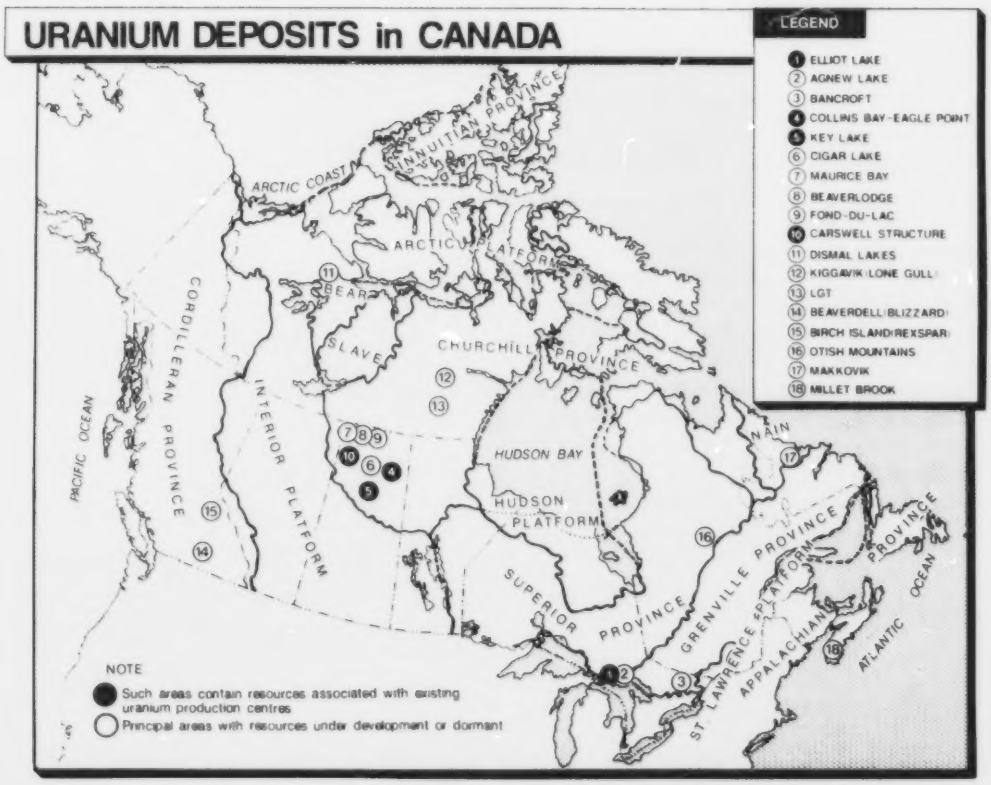


TABLE 2. Operational Characteristics of Existing Canadian Uranium Production Centres

Company and plant location	Deposit type[a] and mining method[b]	Ore-processing plant: Method[c] and recovery[d] (%)	Ore-processing plant: Rated mill capacity/Ore throughput[e] (tonnes/day)	Ore-processing plant: Annual ore milled[e] (tonnes)	Ore-processing plant: Average ore grade processed[e] (% U)
Cluff Mining-Phase II Cluff Lake, Sask.	Ucon/OP/UG	AL/SX/98	900+/750	213 180	0.4
Denison Mines Ltd. Elliot Lake, Ont.	Cong/UG/IPL	AL/IX/93	13 610/7 700	2 550 100	0.08
Eldorado Resources Ltd. Rabbit Lake, Sask.	Ucon/OP	AL/SX/85	1 815/1 940	320 600	0.46
Key Lake Mining Corp. Key Lake, Sask.	Ucon/OP	AL^2/SX/98	700/700+	248 530	1.96
Rio Algom Ltd. Elliot Lake, Ont.					
° Quirke mill	Cong/UG/IPL	AL/IX/94	4 990/4 960	1 656 300	0.08
° Panel mill	Cong/UG/IPL	AL/IX/96	2 990/3 000	981 860	0.1
° Stanleigh mill	Cong/UG/IPL	AL/IX/94	4 540/3 270	1 178 180	0.07

a Deposit types: conglomeratic (Cong), unconformity related (Ucon).

b Mining methods: underground (UG), open-pit (OP), in-place leaching (IPL).

c Ore-processing methods: acid leaching (AL), two-stage acid leaching (AL^2), ion exchange (IX), solvent extraction (SX).

d Actual 1986 mill recovery.

e Actual 1986 mill throughput data (rounded).

In September 1986, operations began at Denison's $10 million joint venture project to recover yttrium oxide as a by-product of uranium production. The new plant, adjacent to the existing Elliot Lake mill facility, has a design capacity of 150 tonnes of yttrium oxide a year, or roughly 35 per cent of western world requirements. Denison brought the plant on-stream within budget and on schedule; partners include Unocal Canada Ltd., Molycorp Inc., Shin-Etsu Chemical Company Ltd. and Mitsui & Company Ltd.

Rio Algom Limited experienced slightly reduced uranium revenues and earnings from its Elliot Lake, Ontario, operations during 1986, mainly due to lower average selling prices and reduced production of uranium. However, the company's ongoing intensive cost-control efforts should continue to offset these factors.

In 1986, Rio Algom and Ontario Hydro renegotiated their uranium supply agreement, whereby total deliveries from the Stanleigh operation from 1986 to 1993 will be reduced by 28 per cent; this is in addition to an earlier reduction of 15 per cent from 1983 to 2004. In an effort to reduce costs, provision was made for exploiting higher grade ore from the adjoining Nordic, Lacnor, and Milliken properties. This provides Rio Algom continuity of its long-term contract and an increased measure of stability, while Ontario Hydro is better able to rationalize its overall uranium supply commitments into the early 1990s.

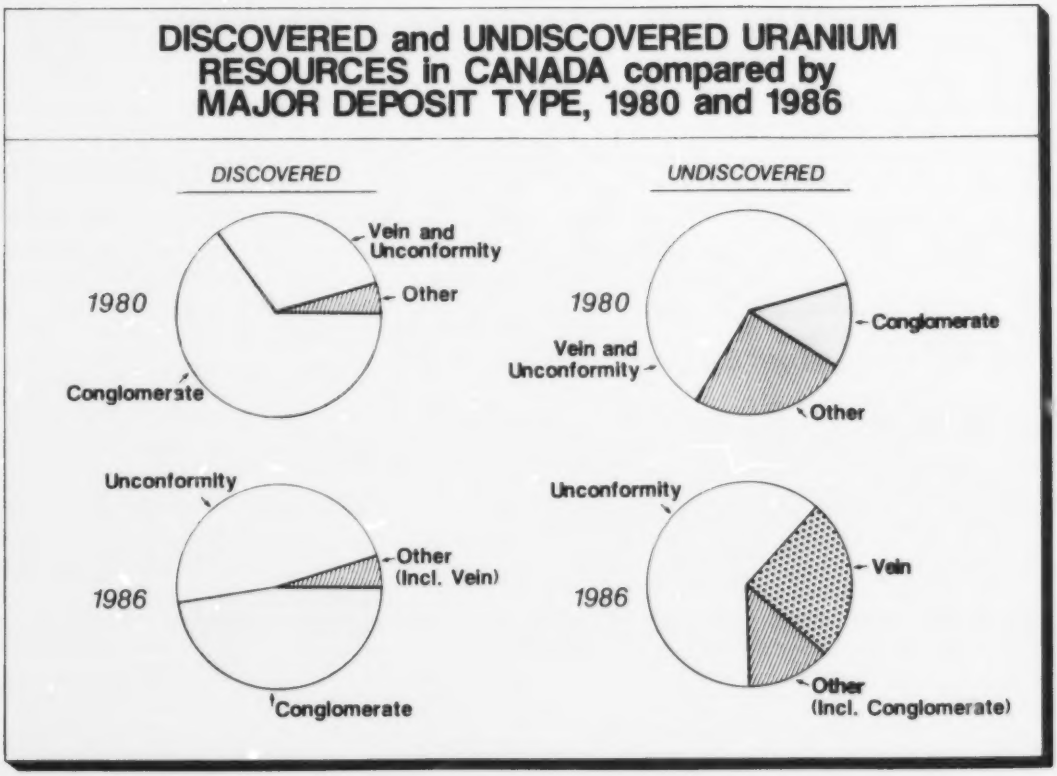
Rio Algom has contracts in place for the delivery of some 15 400 tU from the Quirke, Panel and Stanleigh mines between 1987 and 1995, and a further 22 000 tU from Stanleigh thereafter.

In Saskatchewan, Eldorado Resources Limited (ERL) declared its new Collins Bay "B" mine and the mill circuits at Rabbit Lake to be in commercial operation in mid-1986. The $100 million expansion program was designed to return the Rabbit Lake mill production capacity to 2 000 tU per year; output for the year increased 48 per cent over 1985 levels.

As the Collins Bay "B" orebody is expected to be depleted in the early 1990s, attention will be directed at developing additional resources near Rabbit Lake. In mid-1987, the company submitted its Environmental Impact Statement to the Saskatchewan government, seeking approval to develop the Collins Bay "A" and "D" open-pit orebodies, and the Eagle Point underground deposit. Test work could begin underground at Eagle Point in 1988, following receipt of an Underground Exploration Permit. The high grade and simple mineralogy of the Eagle Point ore is well suited to processing at the new Rabbit Lake mill circuit.

Cluff Mining achieved planned output levels for 1986 at Cluff Lake, Saskatchewan; production from the Dominique-Peter underground mine exceeded expectations by almost 50 per cent and offset the processing of lower grade material from the Claude open pit. The joint-venture partnership is owned 80 per cent by Amok Ltd. and 20 per cent by Saskatchewan Mining Development Corporation (SMDC).

FIGURE 2



Some $2.6 million was spent modifying the Cluff Mining mill to reprocess accumulated radioactive wastes to recover gold and uranium. These mill residues, resulting from the processing of high-grade uranium ore during Phase I of the operation, were placed in concrete vaults as an interim measure pending the selection of final treatment solution. Operations began in March 1987 and the first gold bar was poured in April; all the residues could be processed in about a year.

At the Key Lake mine, development of the Deilmann orebody proceeded ahead of schedule throughout 1986. Activities centre on stripping the Deilmann pit area for mining in 1988; the smaller Gaertner pit was mined out by year-end 1986, although stockpiled ore will provide mill feed during the transition to Deilmann.

Work continues on the heap-leaching tests of cobble ore, as a possible supplement to conventional production. KLMC built a 10 000-tonne heap-leach pile in the summer of 1987 to verify uranium extraction rates from the lower-grade cobble ore; a larger facility may be constructed for possible operation in 1988. KLMC is a joint-venture operating company owned by SMDC (50%), Uranerz Exploration and Mining Limited (33 1/3%) and Eldor Resources Limited (16 2/3%).

As shown in Table 3, some 5100 employees worked at Canada's producing uranium operations as of December 1986. Of this total, 2300 worked in the mines, both open-pit and underground, over 600 in the mills, and the balance were general employees. Head-office and construction-related employment is not included.

FIGURE 3

TABLE 3. Work Force - Canadian Uranium-Producing Operations[a]

Company (operation)	Employees (mine, mill, general)
Cluff Mining	220
Denison Mines Limited	1737
Eldorado Resources Limited (Rabbit Lake)	376
Key Lake Mining Corporation	425
Rio Algom Limited (Quirke)	1132
(Panel)	653
(Stanleigh)	537
Total	5080

[a] as of December 31, 1986

Projected Production Capabilities

To provide an illustration of uranium availability in the short term, Table 4 and Figure 5 show two projections of Canadian production capability to 1996.

These projections of firm production capability are based on existing production centres only, as listed in Table 2. The first assumes levels of production that can be practically and realistically achieved under current circumstances from "A" and "B" priced resources; the second is based on "A" priced resources only.

The lives of some of these production centres could be extended by the exploitation of associated higher priced resources, or through additions of resources in the A plus B price range resulting from continued exploration and development work. No commitments have been made for the start-up of any production centres beyond those currently in operation.

FIGURE 4

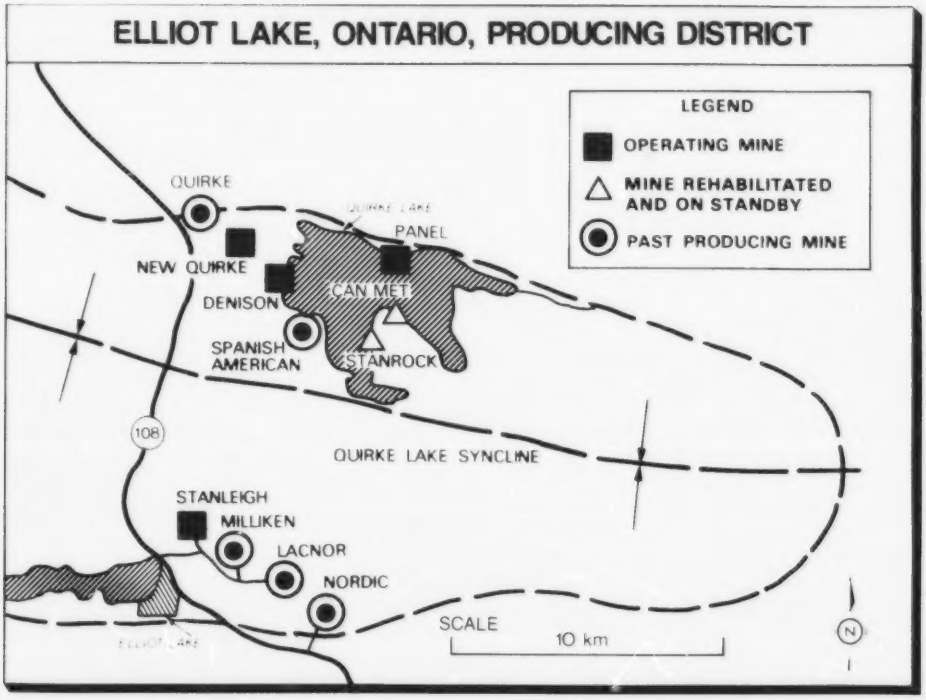


FIGURE 5

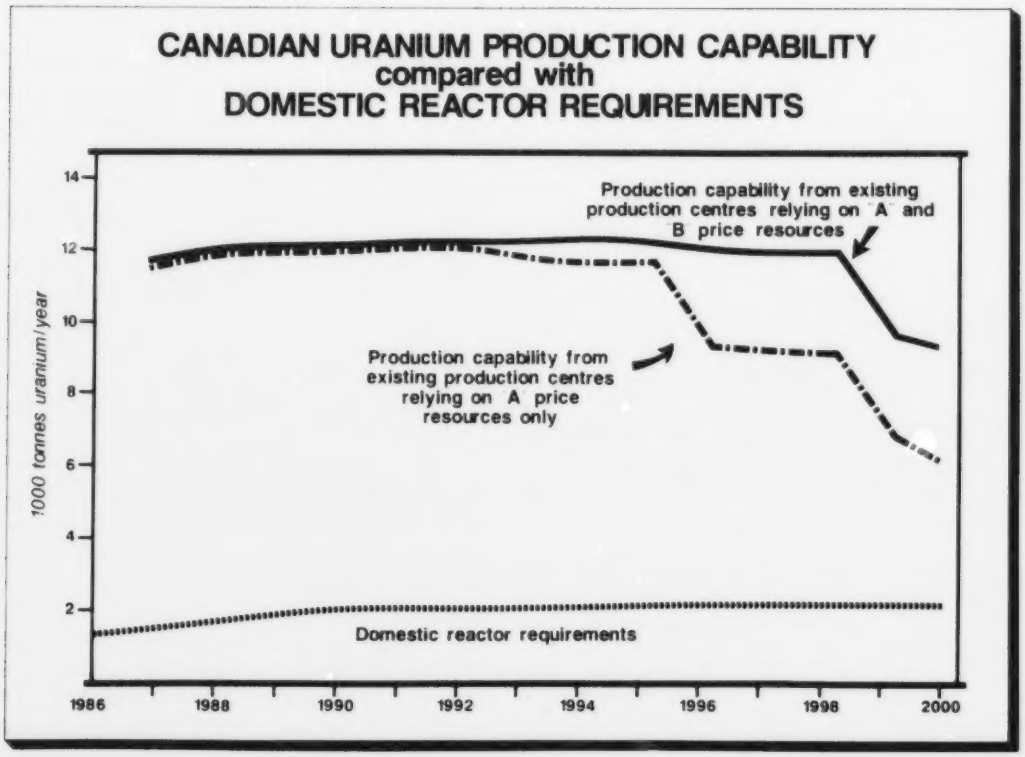


TABLE 4. Canadian Uranium Production Capability From Existing Production Centres

Year	Projection based on "A" + "B" priced resources (tonnes U output)	Projection based on "A" priced resources only (tonnes U output)
1987	11 700	11 700
1988	12 100	12 100
1989	12 100	12 100
1990	12 100	12 100
1991	12 300	12 300
1992	12 300	12 300
1993	12 300	11 800
1994	12 400	11 600
1995	12 300	11 800
1996	12 000	9 400

Additional Production Possibilities

In addition to the existing operations summarized in Table 2 and described above, other projects could become sources of uranium production before the end of the 1990s, should market conditions warrant. These projects are summarized in Table 5.

In late 1986, Cigar Lake Mining Corporation (CLMC) submitted a proposal to the Saskatchewan government for a $40 million underground exploration program, to study the feasibility of various mining methods that could be used to exploit the Cigar Lake deposit. CLMC undertook an Environmental Impact Study in support of the proposal and in mid-1987 was granted an Underground Exploration Permit. Given requisite environmental approvals during 1987, site preparation would commence immediately. The proposed 490-m shaft would be collared before year-end 1987 and finished in 1988; the drifting for the underground mining tests would be completed in 1989. Testing of the three proposed mining methods is scheduled for late 1989. With expectations of final approvals in 1991, production could be envisaged in 1993.

In the Northwest Territories near Baker Lake, Urangesellschaft Canada Limited continues to concentrate on establishing reserves at its Kiggavik (formerly Lone Gull) project, following a 1986 pre-feasibility study. If a production decision is made, output in excess of 1 400 tU annually could be expected from the $200 million project; resources exceed 15 000 tU in ore grading 0.4 per cent U (diluted).

TABLE 5. Possible Future Uranium Production Centres

Project and property location	Operator	Deposit type
SASKATCHEWAN		
Cigar Lake Project, Cigar Lake, Sask.	Cigar Lake Mining Corporation	Unconformity related
Dawn Lake Project, Dawn Lake, Sask.	Saskatchewan Mining Development Corporation	Unconformity related
McClean Lake Project, McClean Lake, Sask.	Minatco Limited	Unconformity related
Midwest Lake Project, Midwest Lake, Sask.	Denison Mines Limited	Unconformity related
OTHERS		
Blizzard Project, Beaverdell, B.C.	Norcen Energy Resources Limited	Surficial
Kitts-Michelin Project, Makkovik, Nfld.	Western Canadian Mining Corporation	Vein and Volcanogenic
Kiggavik (Lone Gull) Project, near Baker Lake, N.W.T.	Urangesellschaft Canada Limited	Unconformity related

In August 1987, Denison Mines Limited announced that, together with a partner, it had acquired a 60 per cent working interest in the Midwest Lake uranium property in northern Saskatchewan for $12 million (50% from Esso Resources Canada Limited and 10% from Numac Oil & Gas Ltd.). Denison will manage the property and is actively assessing the possibility of production in the mid-1990s. Reported drill-indicated resources exceed 20 000 tU in ore grading 1.06 per cent U.

Depending on developments in the uranium market, certain of the projects noted in Table 5 could be brought on stream to increase total Canadian production capability beyond 15 000 tU annually by the mid-1990s. Costs associated with some of these possible new production centres are currently uncertain.

In February 1987, the provincial government of British Columbia permitted the seven-year moratorium on uranium mining and exploration to lapse. It is still uncertain whether uranium activity will resume, as stringent new regulations for uranium exploration in British Columbia may continue to dampen activity.

2. REQUIREMENTS

a) Domestic Nuclear Power Program

The determination of Canada's uranium requirements is based on the estimates of installed nuclear generating capacity shown in Table 6. As of mid-1987, a total of 15 333 MWe of nuclear power capacity was either operating or committed for operation by 1993. In New Brunswick, a second unit at Point Lepreau is envisaged, that would ultimately bring total installed capacity close to 16 000 MWe.

Uranium requirements for this 16 000 MWe of reactor capacity, assessed on the basis of the fuel utilization design values for existing stations, are estimated to be some 63 000 tU for the 30 years required under Canada's uranium

TABLE 6. Nuclear Power Plants in Canada[a]

Reactors	Owner	Net capacity (MWe)	In-service dates
Pickering 1 to 4	Ontario Hydro	2 060	1971-73
Bruce 1 to 4	Ontario Hydro	3 066[r]	1977-79
Point Lepreau	New Brunswick Electric Power Commission	635	1983
Gentilly 2	Hydro-Québec	638	1983
Pickering 5 to 8	Ontario Hydro	2 064	1983-86
Bruce 6 to 8	Ontario Hydro	3 346[r]	1984-87
Darlington 1 to 4	Ontario Hydro	3 524	1988-92[e]
Total net capacity expected by 1993		15 333 MWe	

[a] as of July 1987

[r] revised

[e] expected

policy. The introduction of improved burn-up characteristics could reduce these requirements by about 15 per cent. Annual requirements, including first cores for future reactors, are expected to grow from 1 600 tU/year in 1987 to approximately 2 100 tU/year in 2000, as shown in Table 7.

TABLE 7. Estimated Annual Canadian Uranium Requirements[e]

Year	Tonnes U	Year	Tonnes U
1985[a]	1 300	1989	1 800
1986[a]	1 400	1990	1 800
1987	1 600	1995	2 100
1988	1 700	2000	2 100

e Estimated fuelling requirements for the nuclear power programs of Ontario Hydro, Hydro-Québec, and the New Brunswick Electric Power Commission.

a actual

A measure of domestic uranium resource adequacy can be derived by comparing the 63 000-tonne domestic requirement described above with the conservatively adjusted* estimates of recoverable resources of all companies marketing Canadian uranium. As of December 31, 1986, the total of such resources exceeded by a significant margin the sum of the 30-year domestic requirement plus existing contract commitments.

b) Uranium Sales Commitments

Canadian producers shipped an estimated 11 502 tU in 1986 valued at $1,042 million. Over 85 per cent of these shipments were destined for the export market. The average price of export deliveries in 1986 was $Cdn 89/kg U. Some 21 per cent of export deliveries in 1986 were under spot sales, compared with 20 per cent in 1985, 26 per cent in 1984, 10 per cent in 1983 and only 1.5 per cent in 1982.

Canada's domestic needs for the short term are primarily those required for the Ontario Hydro nuclear power program. Ontario Hydro's two principal uranium supply contracts, approved by the Government of Ontario in February 1978, are with Denison Mines Limited and Rio Algom Limited. These contracts will satisfy the bulk of Ontario Hydro's needs to the early part of the next century, with deliveries scheduled to continue until 2012 and 2020, respectively. Contracts are in place relating to most of the remaining domestic requirements to the end of the century. Total outstanding domestic commitments, as of early 1987, were more than 73 000 tU.

The relative importance of Canada's uranium export customers is shown in Table 8. During the period September 5, 1974, to December 31, 1986, contracts totalling almost 123 000 tU had been reviewed and accepted by the federal government.

* Refer to Appendix 2.

TABLE 8. Uranium Under Export Contracts Reviewed[a] Since September 5, 1974

Country of buyer	Tonnes U
Belgium	3 330
Finland	3 510
France	9 617
Italy	1 120
Japan	25 048
South Korea	5 140
Spain	3 556
Sweden	8 473
Switzerland	150
United Kingdom	7 700
United States	40 990
West Germany	14 330
Total	122 964

[a] Reviewed and accepted under Canadian uranium export policy. Totals adjusted to reflect new and amended contracts, as of December 1986.

The year-end 1986 total reflects scheduled deliveries under more than 160 contracts, over one-third of which remain active.

Total forward export commitments are approximately 62 000 tU, to be delivered over the period 1987 to 2003. Actual exports in 1986 totalled some 9 100 tU, primarily to the United States, Western Europe and Japan (see Table 9).

Japan has been Canada's most important single customer in terms of scheduled deliveries since the start of the commercial contract era. Most of the remaining exports have gone to the European Economic Community, the United States, and other countries in Western Europe. Figure 6 shows the future importance of these Canadian markets in terms of scheduled forward commitments.

TABLE 9. Exports of Uranium of Canadian Origin

Country of final destination	Tonnes of contained uranium[a]				
	1982	1983	1984	1985	1986
Belgium	85	-	121	157	63
Finland	96[r]	179	137	64	116
France	-	435	525	661	1 399
Italy	143	-	50	53	301
Japan	718	663	2 436	1 799	816
Netherlands	-	-	-	-	42
South Korea	74	94	30	194	403
Spain	110	-	-	-	150
Sweden	889	613[r]	254	514	449
Turkey	-	-	-	-	2
United Kingdom	379	675[r]	692	691	700
United States	4 852[b]	860[r]	2 397	3 892	4 001
West Germany	471	490	295	269	654
Total	7 817[r]	4 009[r]	6 937	8 294	9 096

[a] Some of this uranium was first exported to intermediate countries, e.g., France, U.S.A. and U.S.S.R., for enrichment and then forwarded to the country of final destination.

[b] The bulk of this material represents uranium exchanged by Eldorado Resources Limited in the purchase of the Rabbit Lake operation.

[r] revised

Source: Atomic Energy Control Board

FIGURE 6

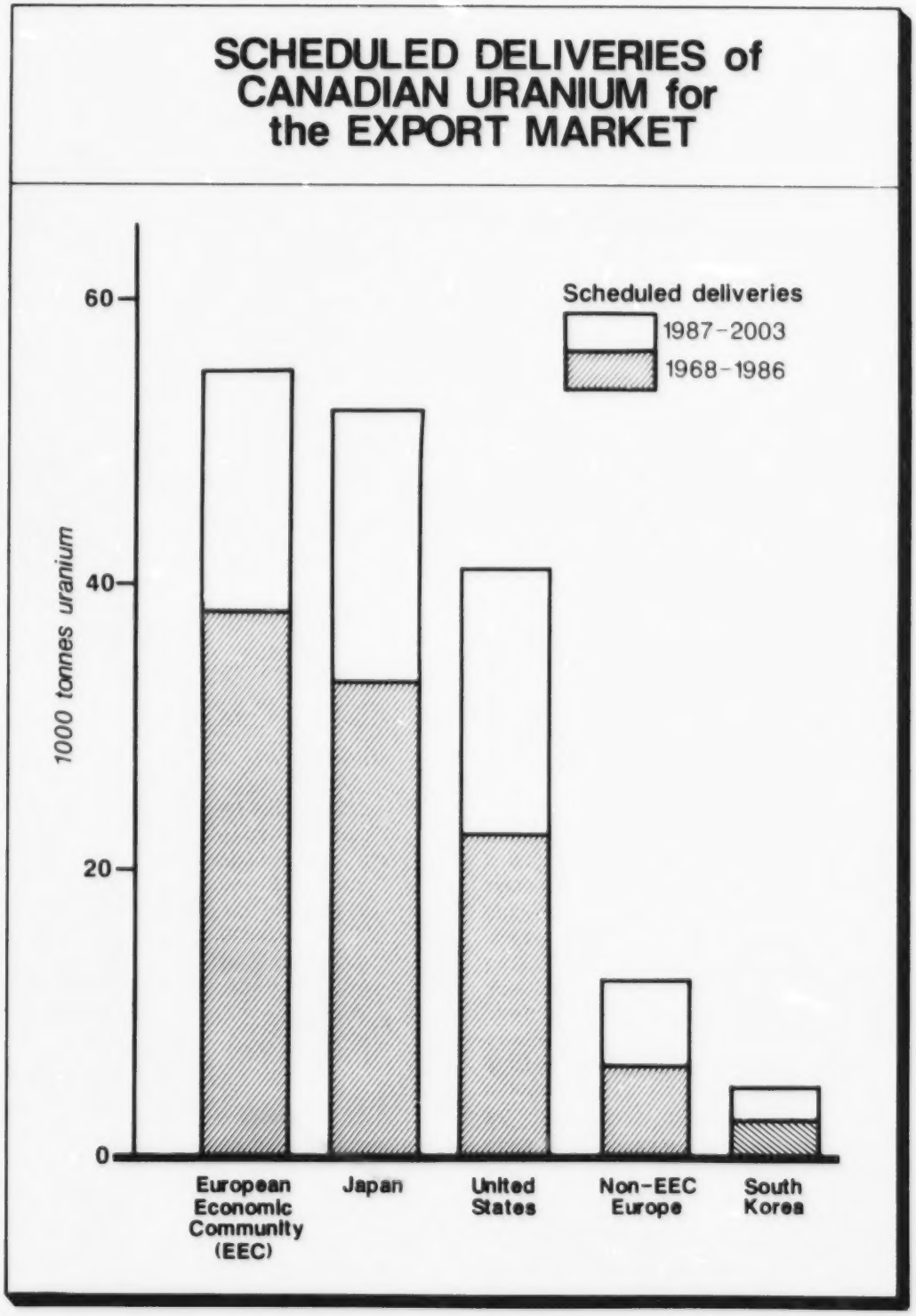

SCHEDULED DELIVERIES of CANADIAN URANIUM for the EXPORT MARKET
Scheduled deliveries
1987-2003
1968-1986
1000 tonnes uranium
60
40
20
0
European Economic Community (EEC)
Japan
United States
Non-EEC Europe
South Korea

TABLE 10. Estimates of Canada's Prognosticated Resources of Uranium Contained in Mineable Ore[a]

Price ranges within which mineable ore is assessed[b]	Thousands of tonnes of uranium	
	1986	1984
A	138	82
B	118	121
C	103	89
A + B + C	359	292

a Uranium recoverable from such ore will be less because of ore-processing losses.

b The price ranges are (A) $100/kg U or less, (B) $100 to $150/kg U, and (C) $150 to $300/kg U.

PART 2. LONGER TERM PERSPECTIVE

1. SUPPLY

a) Supply Sources

The resources described in Part 1 of this report will provide a base for Canadian production beyond the turn of the century. Although deposits at some existing production centres will have been depleted by that time, resources at others are sufficient to permit production into the next century. Several of the recently discovered deposits in northern Saskatchewan may also be developed for production before the end of the century. The higher priced portion of Canada's known resources could also extend production, should market conditions warrant. Beyond these resources there is significant potential for additional discoveries.

It is important to emphasize the distinction between the two types of 'undiscovered' resources, namely prognosticated and speculative. The prognosticated category refers to uranium that is expected to exist in well-defined geological trends containing known deposits. The speculative category refers to uranium that is thought to exist in unexplored areas or in areas where only occurrences are known. A relatively higher degree of confidence can be placed in estimates of the first type of undiscovered resources because of their proximity to, or close association with, well-delineated deposits.

Prognosticated Resources

Estimates of Canada's prognosticated resources of uranium are presented in Table 10, together with the 1984 estimates.

The 1986 URAG assessment of prognosticated resources resulted in a significant restructuring of the estimates, in terms of geological type, economic exploitability and location. Two principal factors influenced this restructuring. One was the continued successful delineation of recent discoveries in Saskatchewan. The other was the protracted slump in uranium prices and upward pressure on production costs. This resulted in a shifting of some prognosticated resources into higher price categories and the elimination of certain low-grade material from the overall total estimates. From Figure 2, it is clear that Proterozoic deposits of the unconformity-related type have become primary exploration objectives.

Speculative Resources

Many other areas of Canada are favourable for the occurrence of uranium resources, in addition to those that are associated with known uranium deposits. Estimates of speculative resources were made during the 1986 assessment for 12 major regions of Canada. Judgments were based on Canada's past production, on distribution of known uranium deposits, and on interpretation of geological features according to conceptual models.

It was concluded that speculative resources may amount to approximately 1 million tonnes of uranium. These resources would be geologically comparable to resources in known deposits that are judged to be mineable at a price of $300/kg U or less. Further resources might exist in areas that have not yet been assessed. It is essential to recognize that a tonnage estimate applied to speculative resources is very qualitative, as it is the result of a probabilistic exercise involving many subjective assumptions, a wide range of uncertainties and an incomplete data base. The bulk of these speculative resources is believed to occur in unconformity-related deposits (see Figure 2).

Additional new uranium-bearing regions may be outlined in Canada as a result of further studies on geologically similar areas outside Canada. For example, the Adelaide geosyncline and adjacent areas of South Australia where the Roxby Downs (Olympic Dam), Mount Painter and Radium Hills uranium deposits occur have analogues in Canada in several areas. The Slave Province in the Northwest Territories, the belt between the Athabasca Basin in northern Saskatchewan and the Baker Lake - Thelon Basin area in the Northwest Territories, the Central Mineral Belt in Nain Province, Labrador, and possibly the north end of Baffin Island should be considered for Olympic Dam-type related deposits.

There is also modest potential for the discovery of so-called "young uranium" deposits in western and eastern Canada. Although difficult to detect, as daughter product development is low, these near-surface deposits are nonetheless attractive economically; while grades may be low, surficial extraction is relatively easy and no significant radioactive tailings remain for disposal. In the semi-arid Okanagan area of British Columbia, deposits containing in the order of a few hundred to a thousand tonnes of uranium are of possible economic significance; in the bog/swamp deposits of northern British Columbia, Manitoba, New Brunswick and Newfoundland, evidence suggests uranium content in the low tens of tonnes.

Uranium Exploration Activities

In terms of the level of total expenditures, uranium exploration activity in Canada increased slightly in 1986, reversing the trend of the previous five years; the preliminary estimate for 1987 expenditures is $36 million, an upward trend that it is hoped will continue. As in the past, efforts in 1986 were concentrated in areas favourable for the occurrence of deposits associated with Proterozoic unconformities, particularly in the Athabasca Basin region of northern Saskatchewan. Although drilling decreased by 12 per cent from 1985 to 1986, as exploration activity was restricted increasingly to established properties with proven resources, grass-roots exploration expanded to new areas in the Northwest Territories and in eastern Canada.

Responses to the 1986 URAG questionnaire revealed the exploration programs of essentially all the companies or joint ventures active in uranium exploration in Canada; some 56 companies participated in 54 active exploration projects, managed by 21 operators. Table 11 summarizes uranium exploration activity in Canada over the past decade.

The ten most active organizations,* accounting for some 97 per cent of the $33 million total, were, in alphabetical order, Amok Ltd., C.E.G.B. Exploration (Canada) Limited, Cigar Lake Mining Corporation, COGEMA Canada Ltd., Eldor Resources Limited, Minatco Limited, PNC Exploration (Canada) Co. Ltd., Saskatchewan Mining Development Corporation (SMDC), Uranerz Exploration and Mining Limited, and Urangesellschaft Canada Limited.

Seven of the ten operators listed above are companies that have their majority interests held outside of Canada and which are supported,

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* In certain cases, the identified operator company has reported the total expenditures of a joint-venture effort. Thus, contributions by other parties not responding to the URAG survey are accounted for in the $33 million total.

directly or indirectly, by their national governments in their uranium exploration efforts.

Figure 7 illustrates the five-year trend in corporate participation in Canadian uranium exploration. Foreign-based companies accounted for just over 55 per cent of overall expenditures in Canada in 1986. Although foreign involvement in uranium exploration in Canada is high and increasing, United States participation has been decreasing and in 1986 represented less than 2 per cent of total expenditures.

FIGURE 7

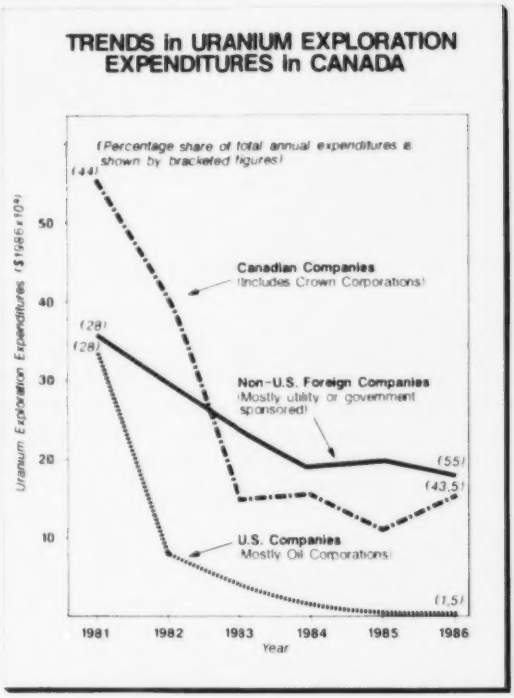


TABLE 11. Uranium Exploration Activity in Canada, 1976 to 1986*

Year	Total expenditures[a] ($million)[c]	Total drilling[b] (km)	Number of projects where expenditures[a] exceeded $1 million[c]
1976	44	155	4
1978	90	334	7
1980	128	503	24
1982	71	247	13
1984	35	197	12
1986	33	162	11

* Refer to Appendix 1 for more exploration activity data.

a Direct exploration and drilling expenditures

b Exploration and surface development drilling; excludes development drilling on producing properties

c Current (reporting year) dollars

In Saskatchewan, exploration was focussed on the southeastern portion of the Athabasca Basin, particularly between Key Lake and Cigar Lake, along the Collins Bay and Eagle Point faults, and in the Carswell Structure, in the western Athabasca Basin. Deep drilling on the Eagle Point deposit resulted in the delineation of additional resources; underground geotechnical testing and bulk ore sample collecting are planned for 1988. The application of different geophysical methods led to the reinterpretation of the structural trends at McClean Lake and hence to the discovery of additional mineralization. Fill-in drilling at Cigar Lake confirmed the original interpolated grades and indicated possible resource increments. In the Northwest Territories, continued survey and drilling work, with data reinterpretation, saw the resource base at the Kiggavik deposit (formerly Lone Gull) expanded; a prefeasibility study indicated mining viability.

Much of the exploration in Saskatchewan in 1986 was based on conceptual genetic models postulating a possible association of the unconformity-type deposits with various structures, environments or processes.

At the Geological Survey of Canada, the conceptual genetic model for deposits in the Athabasca and Thelon Basin regions was refined, as studies on such deposits continue. Five criteria have emerged that may be summarized as follows: 1) there is a relationship between the Archean granitic domes and the location of the deposit; 2) graphitic and pyritic-pelitic conductive layers within the Aphebian sequence are usually present; 3) the deposits are associated with structures and with other features related to the structural framework, typically where the unconformity is intersected by steeply dipping faults or fracture zones; 4) the uranium content in at least some of the rocks in the general area is elevated due to the liberation of uranium and associated metals during paleoweathering and lateritization prior to sedimentary deposition; and 5) the mineralization is differentiated into polymetallic and monometallic mineral assemblages, proportional to the geochemical mobility of the individual components.

A recent EMR study, using URAG exploration expenditure data and published uranium resource estimates, revealed that uranium discovery costs in Saskatchewan from 1930 to 1983 averaged $1.53/kg U expressed in 1985 Canadian dollars; the average cost for Canada as a whole was $2.60/kg U.(3)

b) Uranium Availability

Uranium availability in the longer term will be dependent on a number of factors, the most important of which will be a continuing and developing demand for uranium, and continued access by all producers to the world's markets. Known deposits associated with existing production centres in Canada are capable of supporting significant output levels beyond 1996. In addition, prospective production centres could increase Canada's output level, should markets warrant their development.

To illustrate a range of potential Canadian production possibilities to the end of the century, four projections of production capability are summarized in Table 12. The first two are simply extensions of the short-term projection (based on existing production centres), whereas the other two include anticipated output from certain prospective production centres that could be brought on-stream given favourable developments in the uranium market; all rely only on resources recoverable at uranium prices of $150/kg U or less, i.e., those in the A or the A + B price range. If production is to be in excess of these projected levels, it must come from new discoveries, the realization of which would involve considerable exploration and development.

TABLE 12. Illustrative Projections of Production Capability From Known Canadian Deposits

Year	Tonnes U contained in concentrates			
	I	II	III	IV
1987	11 700	11 700	11 700	11 700
1990	12 100	12 100	12 100	12 100
1995	11 800	12 300	13 000	19 300
2000	6 000	9 300	7 200	16 300

I - Existing production centres supported only by resources in the A price category.

II - Existing production centres supported by resources in the A + B price category.

III - Existing plus Planned and Prospective production centres supported only by resources in the A price category.

IV - Existing plus Planned and Prospective production centres supported by resources in the A + B price category.

It is important to appreciate the long lead-times and inherent risks that are associated with uranium exploration activities. It is not uncommon for 15 years to elapse between the start of an exploration program and first production from a successful discovery. With this in mind, current exploration programs should be focussed on meeting the longer-term needs of Canada and its trading partners. A loss of exploration momentum could jeopardize future supply opportunities.

2. REQUIREMENTS

a) World* Outlook for Nuclear Power Growth

The requirements for Canadian uranium in the future will depend on the growth in nuclear power capacity in the electricity generating systems of Canada and its trading partners.

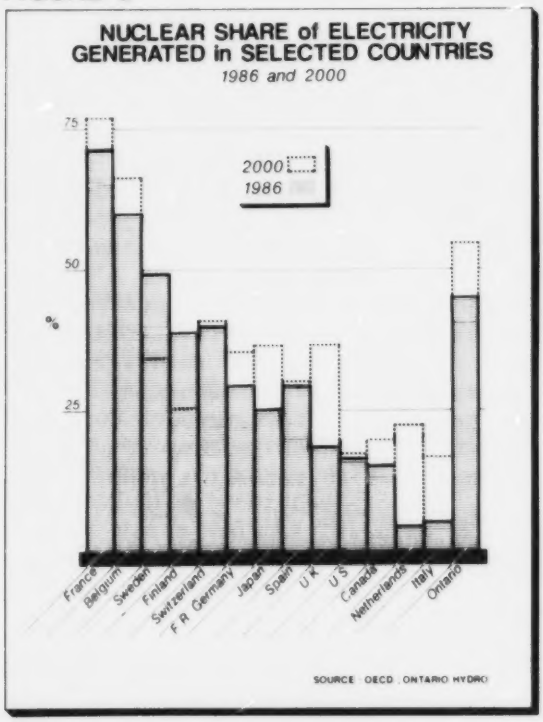
Projections of installed nuclear power capacity, although revised downward in recent years as a result of lower expected rates of economic growth and efforts to introduce energy conservation measures in many countries, continue to reflect a steady

* World, as used here, excludes the U.S.S.R., Eastern Europe and the People's Republic of China.

growth in nuclear power's contribution to world electricity supply (see Figure 8). Canada's total installed nuclear capacity in the year 2000 is expected to reach 16 000 MWe, requiring approximately 2 100 tU per year. Nuclear energy will then be providing nearly 20 per cent of Canada's electricity supply and about 55 per cent of Ontario's.

In OECD countries, installed nuclear power capacity is expected to grow from 224 000 MWe at the end of 1986 to 340 000 MWe by the year 2000, increasing nuclear's overall share of electricity generation to 19 per cent. Related uranium requirements could rise from the current level of some 32 000 tU/year to more than 40 000 tU/year in the early 1990s and could approach 55 000 tU/year by the year 2000.(4/5)

FIGURE 8



Beyond the year 2000, there is a wide range of projections for nuclear power growth, depending on the rate of economic growth and of related requirements for electricity, and on the extent to which nuclear power will penetrate the electricity market. It is possible that total nuclear capacity installed in OECD countries could double or perhaps triple between the years 2000 and 2025. Annual uranium requirements will continue to increase at a modest but steady pace at the very least, and could easily exceed 100 000 tU by the year 2025.(6)

b) Demands on the Uranium-Producing Industry

Canada is among the leaders in terms of estimated uranium resources in all categories, and accounts for a significant proportion of the world's low-cost Reasonably Assured Resources. The NEA/IAEA's* current assessment of world uranium supply illustrates that Canada is one of the most promising countries for the discovery of additional uranium resources.(4/5) Canada has been a reliable uranium supplier to the world market for more than 40 years, and the Canadian government is committed to maintaining that role. Assuming that the international uranium market continues to be free of import and export restrictions, Canada's position as the world's principal exporter of uranium should be maintained well into the next decade. In view of the production capabilities and the potential for additional discoveries, there is every reason to be confident that Canada can maintain its leading role in the world uranium market, while continuing to supply its domestic needs.

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* NEA - Nuclear Energy Agency of the Organisation for Economic Co-operation and Development

IAEA - International Atomic Energy Agency

APPENDIX 1

A. URANIUM EXPLORATION STATISTICS

Uranium Exploration Drilling and Surface Development Drilling Activity in Canada*, 1978 to 1986

Province or territory	1978	1979	1980	1981	1982	1983	1984	1985	1986
	(thousands of metres)								
Saskatchewan	233.4	326.6	368.6	300.7	213.5	120.5	165.8	164.4	153.9
Northwest Territories	18.9	45.6	55.1	22.6	21.5	17.6	17.1	17.2	3.9
Quebec	21.2	19.5	24.1	18.5	12.4	13.4	14.1	1.7	0.0
Nova Scotia	9.7	13.9	16.4	9.3	0.0	0.0	0.0	0.0	0.0
Ontario	11.0	24.2	11.1	3.0	0.0	1.4	0.0	0.0	0.0
New Brunswick	2.8	3.6	9.1	1.0	0.0	0.0	0.0	0.0	0.0
Newfoundland	6.8	20.6	8.1	2.7	0.0	0.0	0.0	0.0	0.0
Manitoba	0.0	2.3	2.9	0.4	0.0	0.0	0.0	0.0	0.0
Alberta	3.9	1.7	1.7	0.6	0.0	0.0	0.0	0.0	4.3
Yukon Territory	0.4	5.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0
British Columbia	25.4	18.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unspecified	0.4	1.4	5.3	0.0	0.0	0.0	0.0	0.0	0.0
Totals (rounded)	334	483	503	359	247	153	197	183	162

* 'Exploration drilling' refers to drilling done in search for new uranium deposits or extensions to known uranium deposits and to drilling at the location of a discovery up to the time that the company decides that sufficient ore has been delineated to justify commercial exploitation. 'Surface development drilling' refers here to drilling subsequently done to determine more precisely a deposit's size, grade and configuration, and excludes development drilling on producing properties.

APPENDIX 1

B. URANIUM EXPLORATION STATISTICS

Uranium Exploration Expenditures in Canada*, 1978 to 1986

Province or territory	1978	1979	1980	1981	1982	1983	1984	1985	1986
	(millions of current Canadian dollars)								
Saskatchewan	43.6	70.5	77.2	60.8	47.9	27.3	24.8	23.5	28.9
Northwest Territories	17.0	26.4	29.1	23.6	13.2	7.3	6.4	6.2	2.5
Quebec	7.4	7.0	6.4	8.8	8.4	5.6	3.3	1.0	0.05
Nova Scotia	2.4	3.8	4.5	3.0	0.0	0.0	0.0	0.0	0.0
Newfoundland	2.8	6.8	3.7	1.6	0.3	0.4	0.4	0.3	0.0
Ontario	2.3	2.1	1.7	0.9	0.4	0.2	0.0	0.0	0.0
New Brunswick	1.2	2.3	1.4	0.8	0.2	0.2	0.0	0.0	0.0
Yukon Territory	1.0	2.7	1.3	0.7	0.3	0.0	0.06	0.2	0.2
Manitoba	0.2	0.6	1.1	0.2	0.0	0.0	0.0	0.0	0.0
Alberta	1.1	1.6	1.0	1.1	0.0	0.0	0.06	0.4	0.8
British Columbia	7.0	3.9	0.6	0.1	0.0	0.0	0.0	0.0	0.0
Unspecified	4.0	1.8	0.3	0.5	0.0	0.0	0.06	0.2	0.07
Totals (rounded)	90	130	128	102	71	41	35	32	33

* Expenditures on exploration and surface development drilling and all other costs directly associated with uranium exploration activities, excluding land acquisition. Overhead charges not directly associated with such activities are not included.

APPENDIX 1

C. URANIUM EXPLORATION STATISTICS

Total Expenditures and Coverage of Government-Sponsored Radiometric and Geochemical Surveys

Year	Area covered		Expenditures[a]		
	Radiometric	Geochemical[b]	Radiometric	Geochemical	Total
	(km^2)		($ million)		
Pre-79	1 980 000[c] 5 500[d]	1 033 000	9.054	8.052	17.106
1979	13 000[c] 17 000[d]	75 000	0.270	0.785	1.055
1980	63 000[c] 8 500[d]	47 000	0.206	0.470	0.676
1981	7 500[d]	74 000	0.112	0.540	0.652
1982	60 000[c] 17 500[d]	94 000	0.442	0.750	1.192
1983	19 500[c] 22 500[d]	99 000	0.397	0.784	1.181
1984	75 500[c] 22 000[d]	96 000	0.616	0.647	1.263
1985	34 000[d]	160 400	0.640	1.138	1.778
1986	57 000[c] 25 500[d]	184 100	0.738	1.568	2.306
1987[e]	27 500[d]	143 000	0.551	1.489	2.040
Total	2 455 500	2 005 500	13.026	16.223	29.249

a In $Cdn for the survey year, includes federal and provincial funding.
b Includes provincial surveys to National Geochemical Reconnaissance (NGR) standards.
c 5-km line spacing d 1-km line spacing e estimate

Note: It should be noted that these surveys have been designed since their inception for the purpose of assisting mineral exploration and geological mapping in general, in addition to their specific relevance to uranium.

APPENDIX 2

DEFINITIONS OF RESOURCE AND PRODUCTION TERMINOLOGY

In its annual uranium resource assessment, the Uranium Resource Appraisal Group (URAG) divides its estimates into five separate categories reflecting different levels of confidence in the quantities reported. These categories are further separated into three levels of exploitability related to the current price of uranium.

The following terms and definitions used by URAG are in harmony with those used by Energy, Mines and Resources Canada (EMR) for non-fuel mineral and coal resource assessment.

Ore is a natural mineral-bearing substance that can be recovered by mining and from which one or more commodities can be extracted economically under conditions specified at the time of the appraisal.

Measured ore refers to ore for which tonnage is computed from dimensions revealed in outcrops, trenches, workings, or drill-holes, and for which grade is computed from adequate sampling. The sites for inspection, sampling and measurement are so closely spaced and the geological character is so well defined that the size, shape and mineral content are well established. The tonnage and grade should refer to ore recoverable by mining with due regard for dilution.

Indicated ore refers to ore for which tonnage and grade are computed partly from specific measurements, samples, or production data and partly from projection for a reasonable distance on geological evidence. The openings or exposures available for inspection, measurement and sampling are too widely or inappropriately spaced to outline the ore completely or to establish its grade throughout.

Inferred ore refers to ore for which quantitative estimates are based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. Estimates are based on assumed continuity or repetition for which there is geological evidence; this evidence may include comparison with deposits of similar types. Bodies that are completely concealed, but for which there is some geological evidence, may be included. Estimates of inferred ore should include a statement of the specific limits within which the inferred material may lie. These limits vary depending upon the characteristics and knowledge of the orebodies.

Prognosticated resources refer to estimated tonnages beyond specific limits established for inferred ore. They may include tonnages of portions of identified orebodies or of concealed satellite orebodies, the existence of which can be assumed along well-established geological trends associated with known deposits. The attributes of prognosticated resources are, as a rule, derived by extrapolation from identified deposits or by quantification of geological information.

Speculative resources refer to estimated tonnages in deposits thought to exist on the basis of indirect indications and geological extrapolations in unexplored areas or in areas where only occurrences are known. These resources would be geologically comparable to resources in known deposits that are judged to be mineable at prices below a given level.

Reserves refer only to those measured and indicated resources that could be mined at the uranium market price as determined at the time of the assessment (equivalent to block 1A of Figure A-1) unless another price is specified.

For categorization by price level (i.e., level of economic exploitability), cut-off grades are chosen that cover all costs of production after due consideration of processing losses, plus any required forward capital costs. The difference between the cut-off grade and the average grade of the resources for each individual deposit is then examined to determine if the difference is sufficient to carry such items as taxes and royalties, head office overhead, forward exploration and development costs, and an acceptable rate of return on invested capital (i.e., costs associated with the use of capital). If the difference between the chosen cut-off grade and the average grade is judged sufficient, the tonnage is taken to be mineable at a price below the stated limit.

Except where otherwise stated, resource estimates in the measured, indicated and inferred categories refer to quantities of uranium recoverable from mineable ore, as opposed to quantities of uranium contained in mineable ore, or uranium contained in-situ (i.e., deductions have been made for both mining and ore processing losses). In the case of the prognosticated category, resource estimates are expressed in terms of quantities of uranium contained in mineable ore. Speculative resource estimates are expressed as in-situ quantities.

For national and international purposes, Canadian resource estimates are often quoted in terms of the international uranium resource definitions employed by the NEA and the IAEA, in their assessments of world uranium resources, which are prepared as a joint exercise on a regular basis. The terms Reasonably Assured Resources (RAR) and Estimated Additional Resources (EAR) and their definitions were first developed in 1964 and were retained until recently, with only minor modification, in periodic joint NEA/IAEA world uranium supply assessments. It is pertinent to note that, in 1975, the NEA/IAEA changed its resource definitions to refer to 'cost' instead of 'price', while Canada has retained the price classification.*

The term Speculative Resources was introduced by the NEA/IAEA in 1978, in the recognition that assessments covering only RAR and EAR represented an incomplete appraisal of the world's uranium resources. In late 1982, the NEA/IAEA redefined its EAR category to distinguish between the discovered and the undiscovered components of those additional resources that are expected to occur in association with known deposits.(2) These two components have been termed Estimated Additional Resources - Category I (EAR-I) and Estimated Additional Resources - Category II (EAR-II), respectively.

The NEA/IAEA resource definitions are as shown below. Their relationship to definitions used in EMR's annual assessment of uranium resources is illustrated in Figure A-1.

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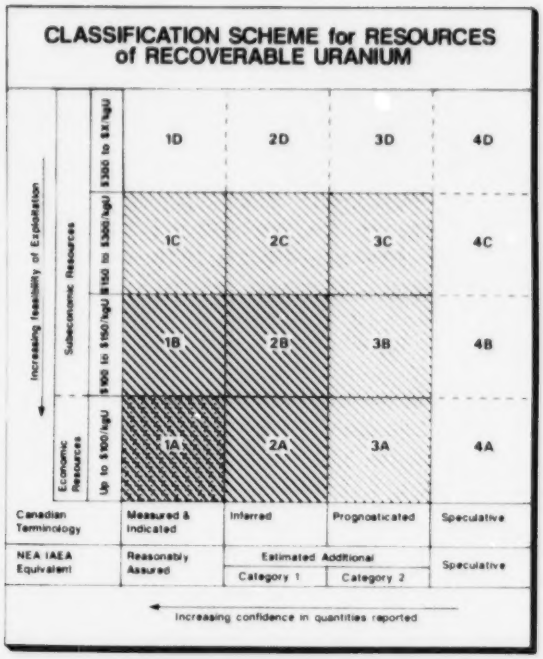
* For purposes of international comparison Canada's three defined 'price' categories may be considered equivalent to the NEA/IAEA's three defined 'cost' categories, from the lowest to the highest, respectively. The three defined cost/price categories are illustrated by blocks labelled A, B and C, respectively, in Figure A-1.

FIGURE A-1



Reasonably Assured Resources (RAR) refers to uranium that occurs in known mineral deposits of such size, grade and configuration that it could be recovered within the given production cost ranges, with currently proven mining and processing technology. Estimates of tonnage and grade are based on specific sample data and measurements of the deposits and on knowledge of deposit characteristics. Reasonably Assured Resources have a high assurance of existence.

Estimated Additional Resources - Category I (EAR-I) refers to uranium in addition to RAR that is expected to occur, mostly on the basis of direct geological evidence, in extensions of well-explored deposits, and in deposits in which geological continuity has been established but where specific data and measurements of the deposits and knowledge of their characteristics are considered to be inadequate to classify the resource as RAR. Such deposits can be delineated and the uranium subsequently recovered, all within the given cost ranges. Estimates of tonnage and grade would be based on such sampling as is available and on knowledge of the deposit characteristics as determined in the best known parts of the deposit or in similar deposits. Less reliance can be placed on the estimates in this category than on those for RAR.

Estimated Additional Resources - Category II (EAR-II) refers to uranium in addition to EAR-I that is expected to occur in deposits believed to exist in well-defined geological trends or areas of mineralization with known deposits. Such deposits can be discovered, delineated and the uranium subsequently recovered, all within the given cost ranges. Estimates of tonnage and grade would be based primarily on knowledge of deposit characteristics in known deposits within the respective trends or areas and on such sampling, geological, geophysical or geochemical evidence as may be available. Less reliance can be placed on the estimates in this category than on those for EAR-I.

Speculative Resources (SR) refers to uranium, in addition to EAR-II, that is thought to exist mostly on the basis of indirect evidence and geological extrapolations, in deposits discoverable with existing exploration techniques. The location of deposits envisaged in this category could generally be specified only as being somewhere within a given region or geological trend. As the term implies, the existence and size of such resources are highly speculative.

In presenting its definitions, the NEA/IAEA emphasizes that the distinctions drawn between the four categories of resources (RAR, EAR-I, EAR-II and SR), based on differing degrees of geological evidence, make it essential that each category be regarded as a discrete entity. Therefore, great care should be taken in the use of resource estimates (e.g., not summing estimates of all four categories to obtain 'total resources').

With the increased emphasis that has been placed on projections of production capability as illustrations of uranium supply possibilities, it was necessary to formalize a number of terms used in the description of such projections. The NEA/IAEA introduced the following terms in its December 1983 assessment of world uranium supply. These terms are used throughout this report.

A PRODUCTION CENTRE, as referred to in this report, is a production unit consisting of one or more ore processing plants, one or more associated mines and the resources that are tributary to them. For the purpose of describing production centres, they have been divided into four classes, as follows:

a) EXISTING Production Centres are those that currently exist in operational condition and include those plants which are closed down but which could be readily brought back into operation.

b) COMMITTED Production Centres are those that are either under construction or are firmly committed for construction.

c) PLANNED Production Centres are those that are planned, based on feasibility studies that are either completed or underway, but for which construction commitments have not yet been made. This class also includes those plants that are closed which would require substantial expenditures to bring them back into operation.

d) PROSPECTIVE Production Centres are those that could be supported by tributary RAR and EAR-I, i.e., 'known resources,' but for which construction plans have not yet been made.

PRODUCTION CAPACITY denotes the nominal level of output, based on the design of the plant and facilities over an extended period under normal commercial operating practice.

PRODUCTION CAPABILITY refers to an estimate of the level of production that could be practically and realistically achieved under favourable circumstances from the plant and facilities at any of the types of production centres described above, given the nature of the resources tributary to them. (Normally, projections of production capability are supported only by RAR and/or EAR-I.)

ADJUSTED RECOVERABLE RESOURCES for the purpose of monitoring domestic uranium resource adequacy, are equivalent to the sum of resources in the measured, indicated and inferred categories, weighted by factors of 1.0, 0.8 and 0.7, respectively, recoverable from mineable ore at prices of $150/kg U or less.

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